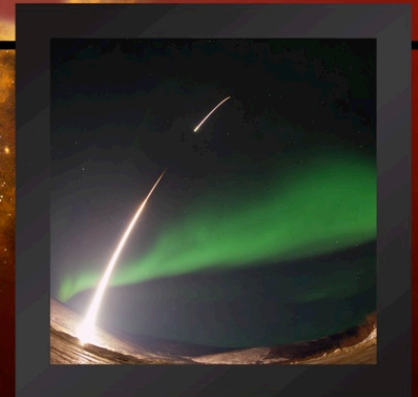
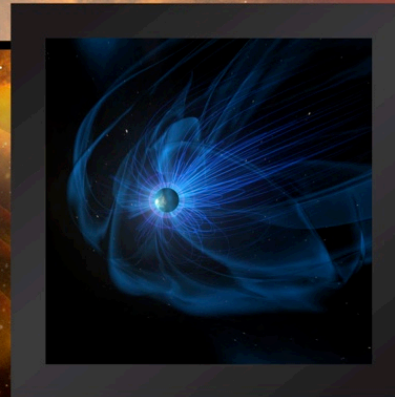
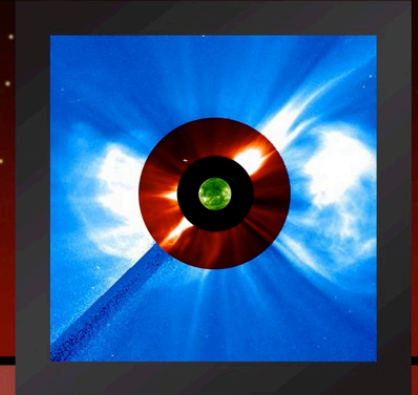
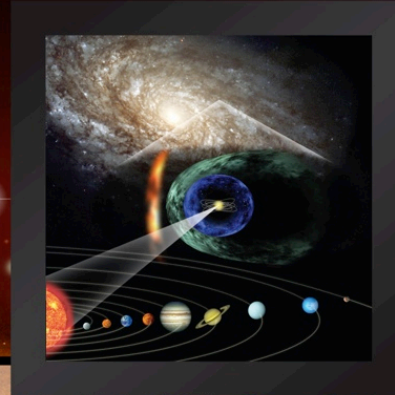




HELIOPHYSICS DIVISION



Heliophysics CubeSats
June 2015
Jeffrey Newmark

■ Mission Statement

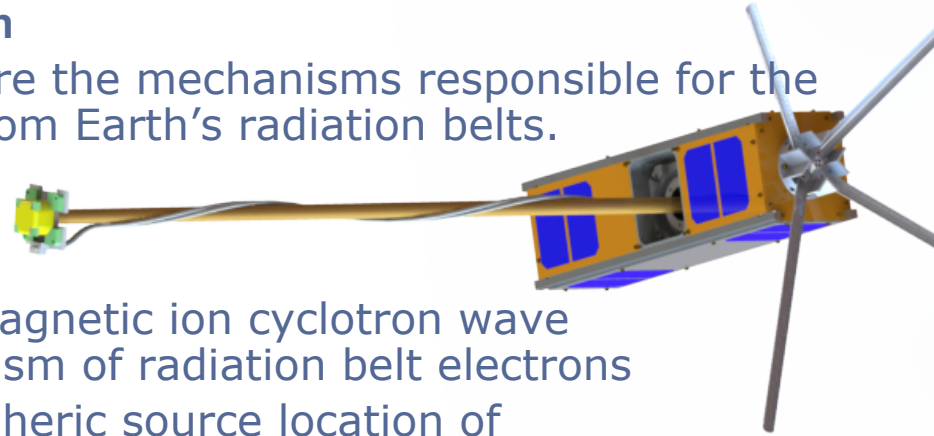
- **Electron Losses and Fields Investigation**
- The ELFIN CubeSat mission will explore the mechanisms responsible for the loss of relativistic, “killer” electrons from Earth’s radiation belts.

■ Mission Objectives

- Primary: Determine whether electromagnetic ion cyclotron wave scattering is the primary loss mechanism of radiation belt electrons
- Secondary: Determine the magnetospheric source location of ionospheric field-aligned currents powering the auroras

■ Approach

- Primary: Measure the angle and energy distribution of precipitating electrons and determine if they bear the characteristic signature of scattering by electromagnetic ion cyclotron waves
- Secondary: Measure the magnetic signature of field aligned currents. Constrain magnetic models, by modeling where ion and electron fluxes become isotropic, and use these models to map the field aligned currents to the magnetosphere



■ The Phenomenon

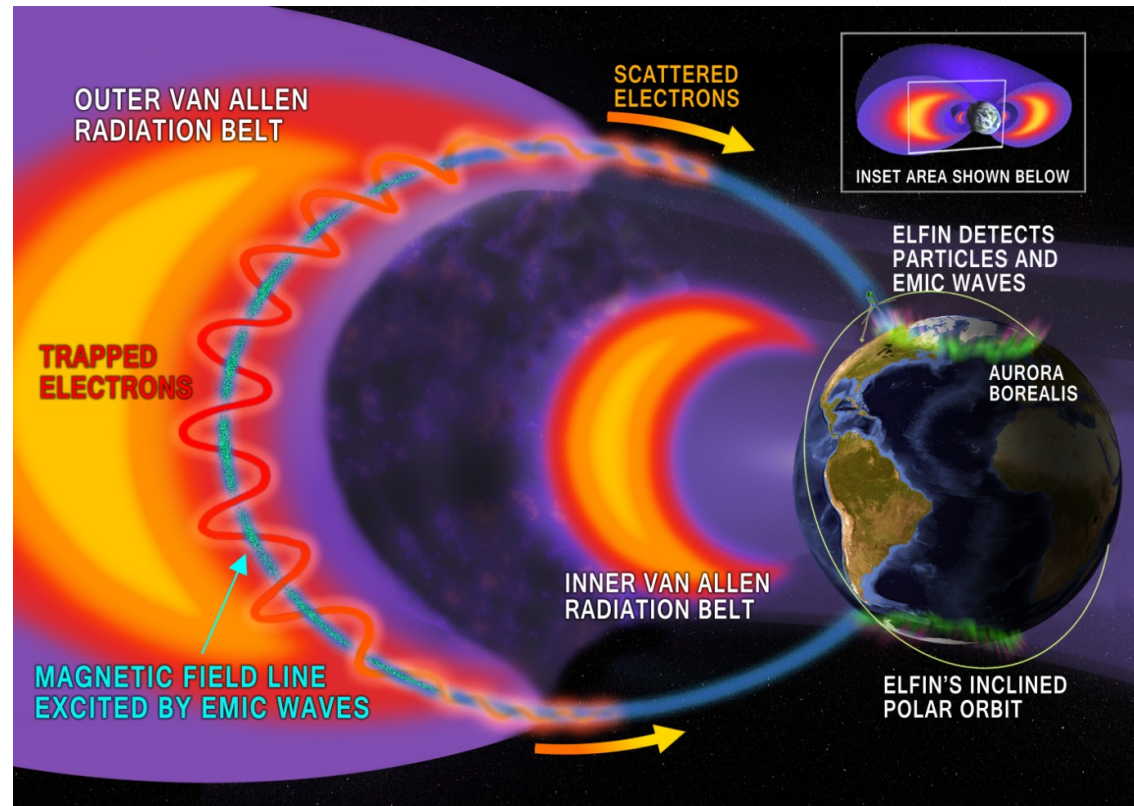
Charged particles become trapped inside Earth's magnetic field.
Scattering causes trapped electrons to precipitate into the atmosphere.

■ The Problem

Space weather forecast models are incomplete, due to our poor understanding of what controls radiation belt energetic electron fluxes. Acceleration, transport and loss controls these fluxes but losses have been inadequately quantified thus far.

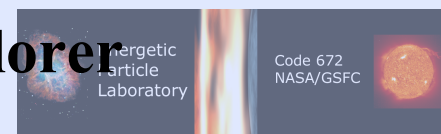
■ Closure

ELFIN will measure loss rates during storms and test our theoretical models of the dominant wave scattering mechanisms.



CeREs: A Compact Radiation Belt Explorer

PI Shri Kanekal, GSFC



Mission

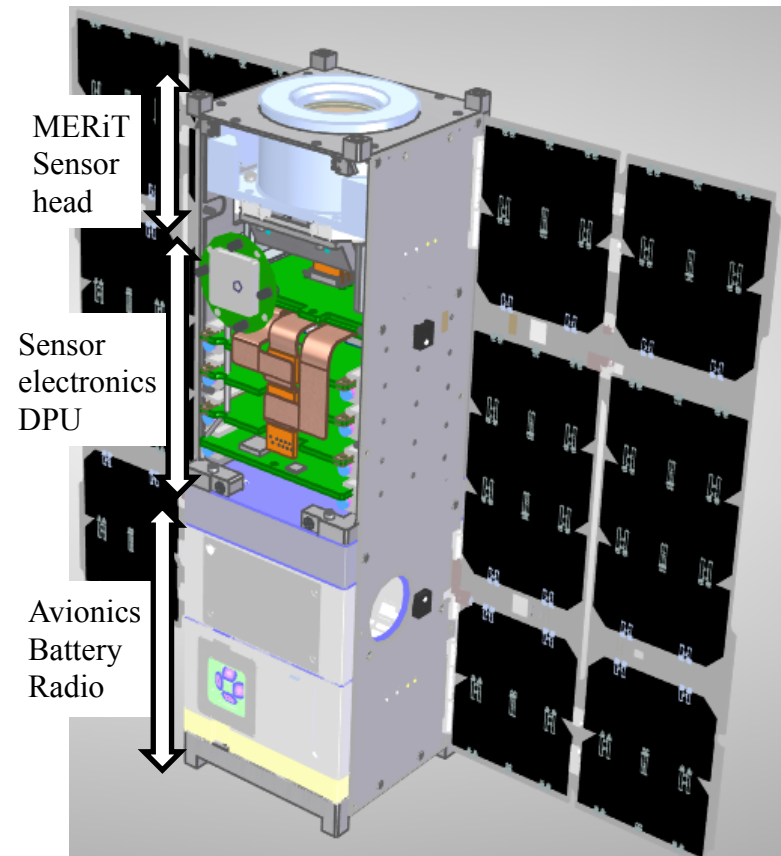
- First fully-NASA funded CubeSat
- 3U s/c with 1.5U each for payload and bus
- Expected launch November 2016
- High inclination sun-synchronous LEO
- Co-I institution - SWRI

Payload

- Miniaturized Electron Proton Telescope (MERiT)
 - Compact innovative particle sensor using solid state and avalanche photodiode detectors
 - e⁻ : ~10keV to ~10MeV $\Delta E=30\%$ $\Delta t=5\text{ms}$
 - p : ~200keV to ~100MeV $\Delta E=30\%$ $\Delta t=1\text{mn}$

Science

- Radiation belt electron dynamics (**primary**)
 - Are microbursts capable of emptying rad. Belts?
- Solar electron energization and transport (**secondary**)
 - How & where are supra-thermal electrons energized ?
- Solar proton access to Geospace (**space weather**)
 - How strong are space weather effects of SEP proton during geomagnetic storms?

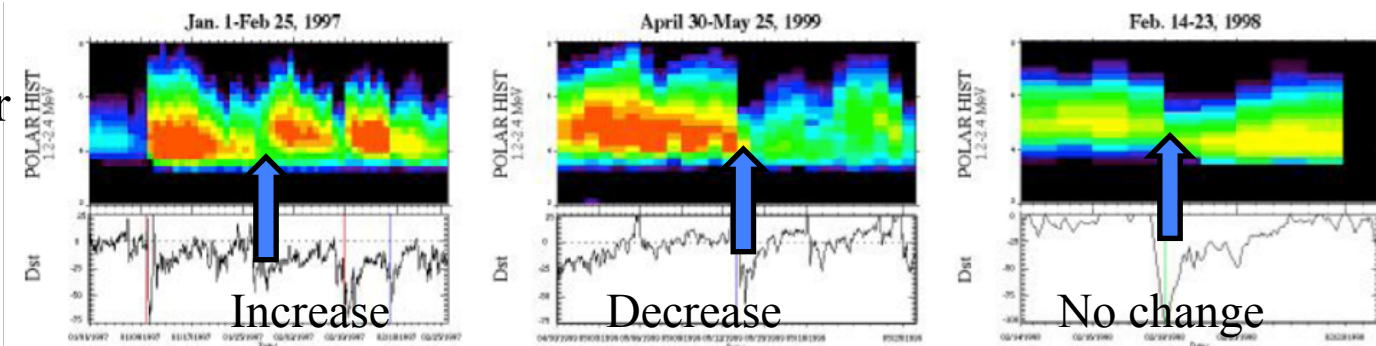


CeREs primary science

Electron loss due to microbursts

Electron intensity after geomagnetic storm

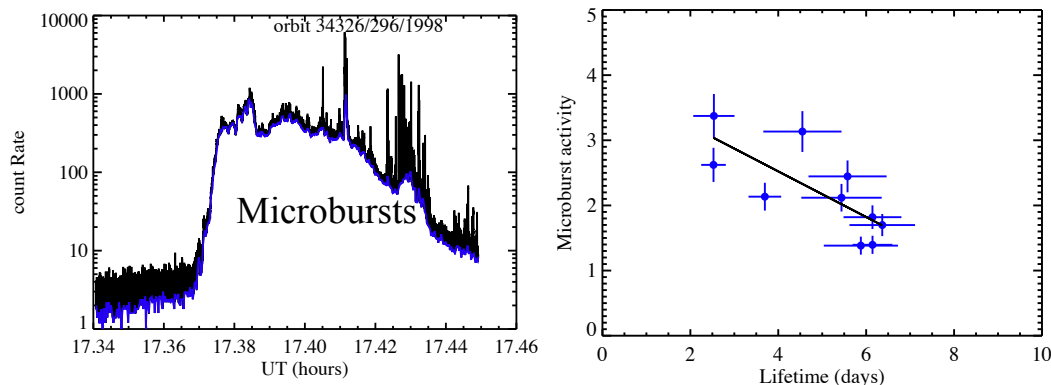
- balance between energization and loss



Therefore it is important to quantify loss due to various processes

Earlier SAMPEX measurements

- higher microburst activity
- ➡ lower electron flux lifetime

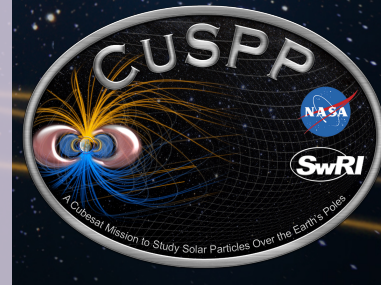


Expected CeREs measurements

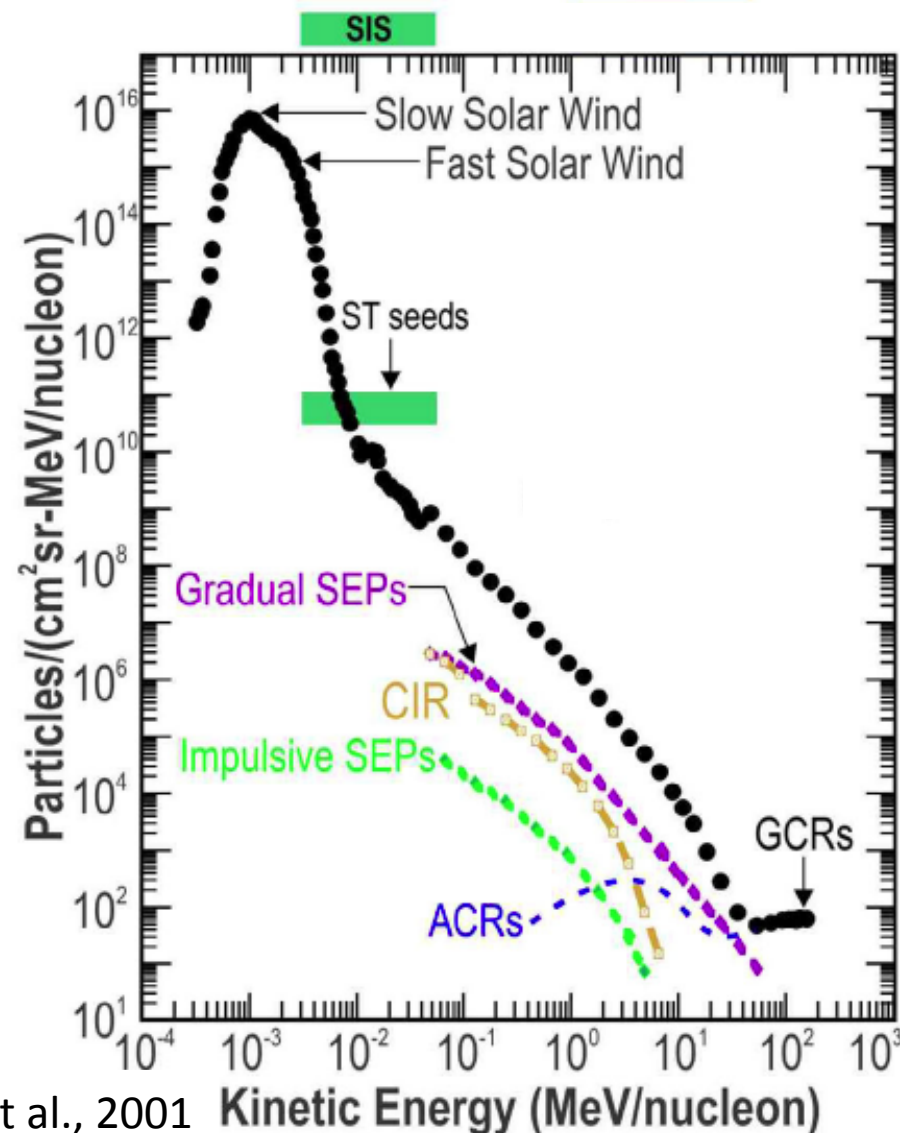
- 5 times higher time resolution (4ms compared to 20ms)
- Spectral information of electrons (none earlier)
- Overlap with Van Allen Probes particle and wave measurements to provide a complete and comprehensive picture



CuSPP Science Objective & Strategy



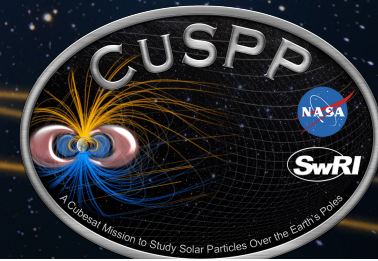
- **Cu**beSat mission to study **S**olar **P**articles over the Earth's **P**oles
- Suprathermal ion tails are ubiquitous throughout the heliosphere
- Comprise material from many sources – highly variable in time and space
- Current instruments not optimized to measure suprathermal ions
- Top priority for NASA's Heliophysics Division & notional mission Interstellar Mapping and Acceleration Probe in the 2012 Decadal Survey
- CuSPP measures solar and interplanetary suprathermal ions that enter the Earth's polar regions via open field lines



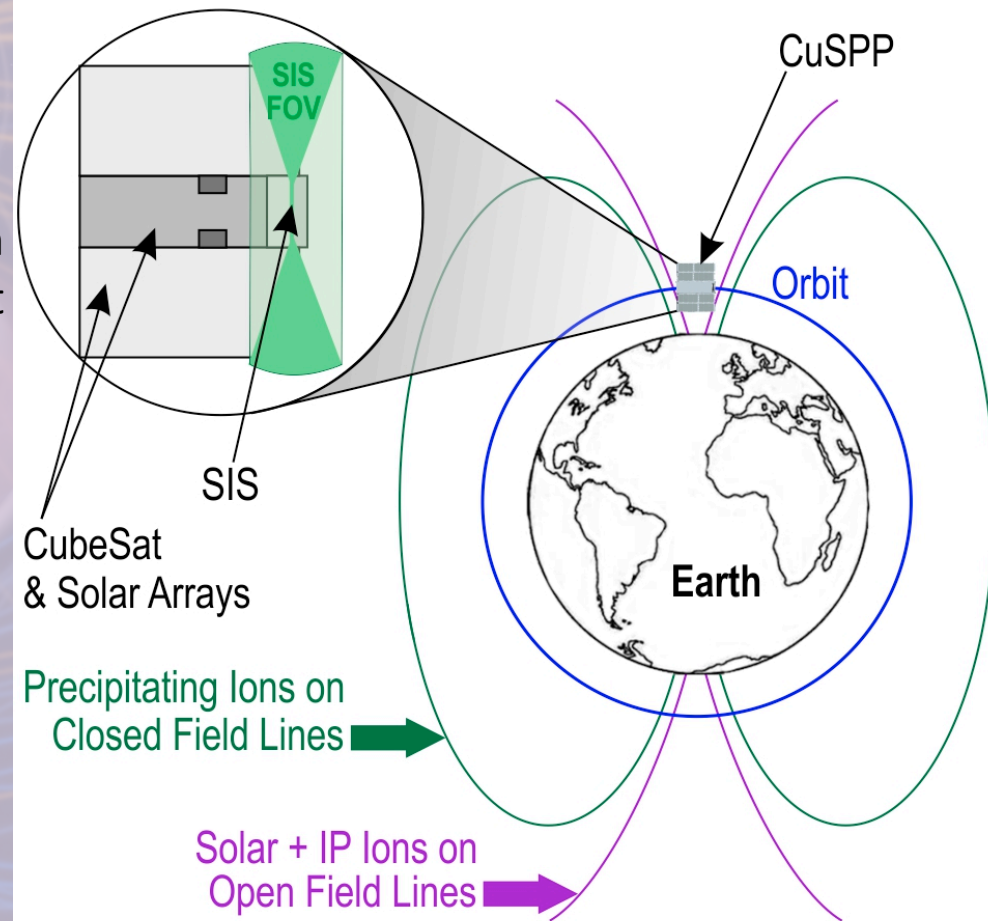
Mewaldt et al., 2001



CuSPP Mission



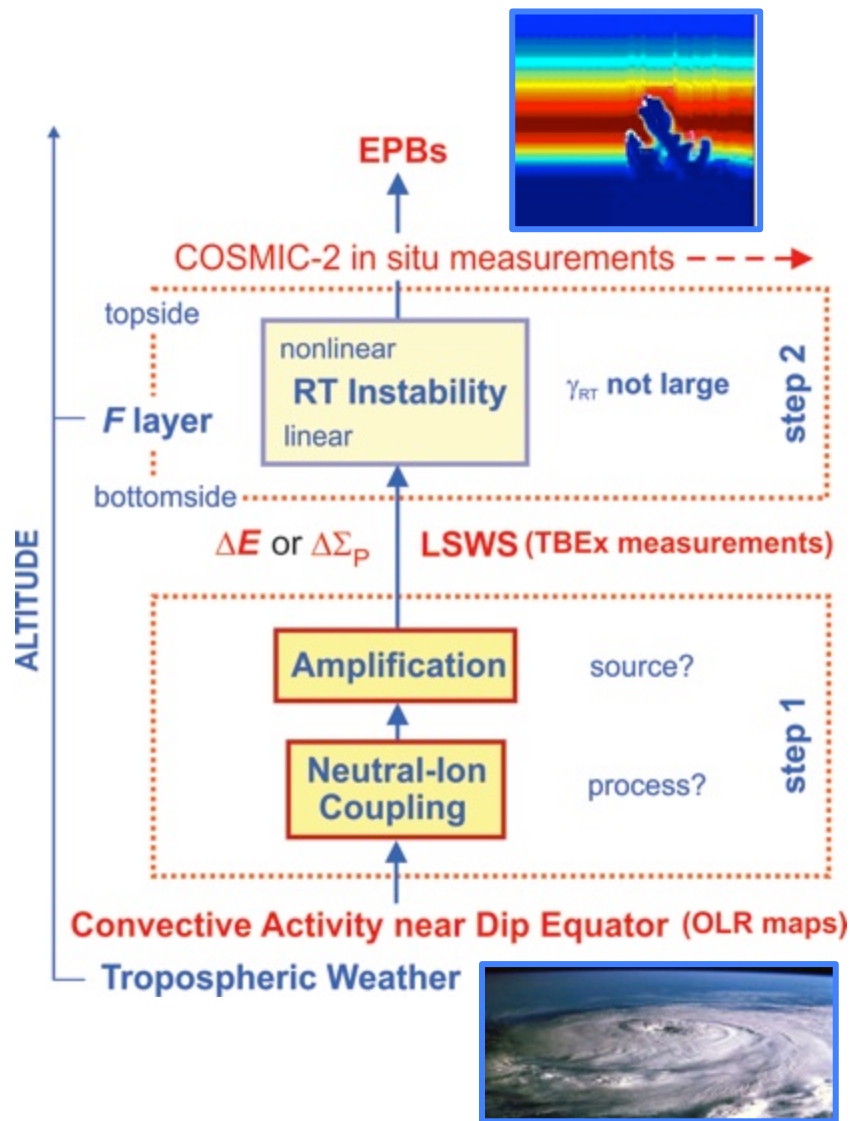
- 3U CubeSat under H-TIDES LCAS
 - Measures solar and interplanetary suprathermal ions
 - Increases the TRL of a next generation Suprathermal Ion Sensor (SIS) concept
 - Trains SwRI/UTSA graduate students, early-career scientists & engineers
- Low-Earth Orbit:
 - ~500 km altitude
 - >65° inclination
 - ~95 minute period
- Launch: as early as Aug. 2016;
Duration: design >3 months (goal 1 year)
- Status of S/C subsystem
 - Architecture and fit check of Centaur Avionics board completed



Tandem Beacon-Explorer (TBEx): Science Goals/ Relevance to Broader Heliophysics Goals

- TBEx will address a scientific challenge in 2012 NRC Decadal Survey: Understand how forcing from lower atmosphere acts through plasma-neutral coupling processes to give rise to local, regional, and global-scale structures and dynamics in the atmosphere-ionosphere-magnetosphere system
- TBEx will monitor (1) response of bottomside F layer to wavelike disturbances from below, with sampling intervals less than orbital period, and (2) development of equatorial plasma structure, including 'equatorial plasma bubbles' (EPBs)
- TBEx mission is expected to provide a better understanding of the physics that controls the day-to-day variability in development of EPBs (space weather)

Causal Link: Convective Activity to EPBs

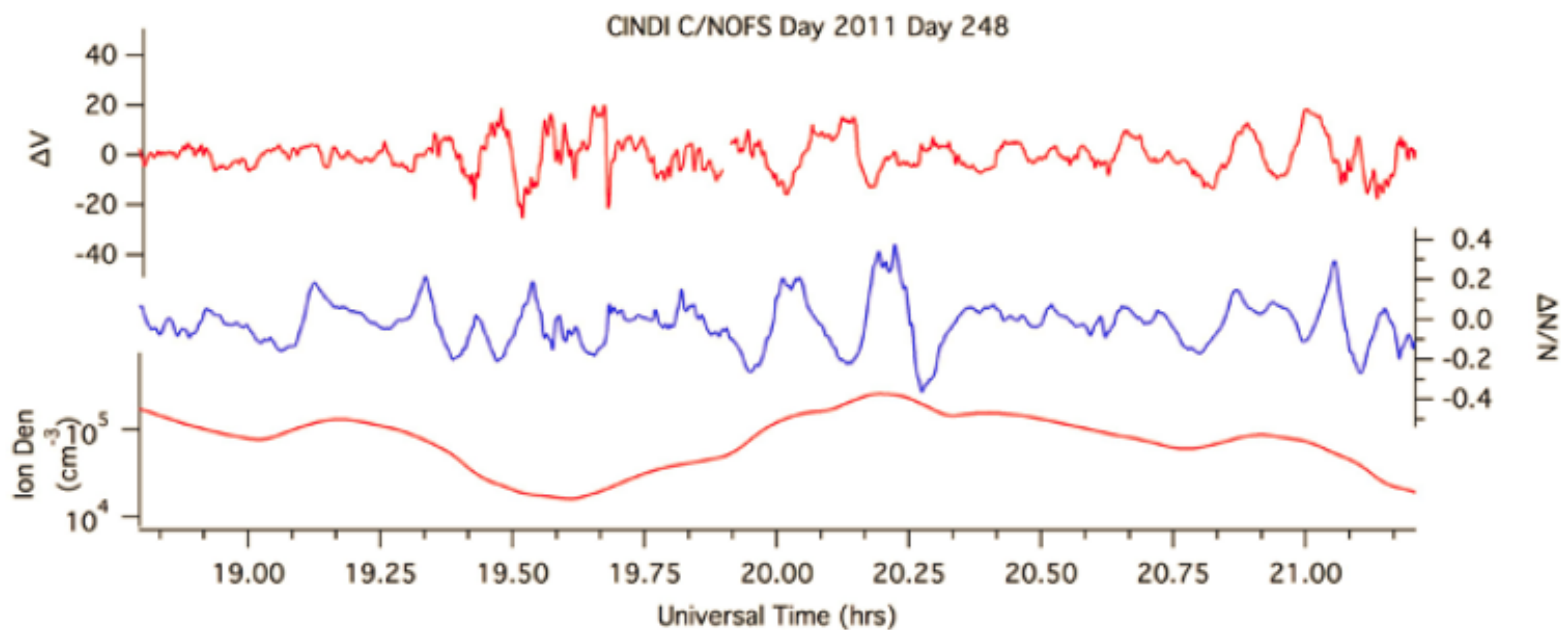


- OLR maps: monitor presence and distribution of convectively active regions (input: stage 1)
- TBEx measures LSWS from VHF-L band TEC variations, measured with cluster of ground receivers (output: stage 1; input: stage 2)
- COSMIC-2 in situ sensors and ground-based radar measure EPBs (output: stage 2)
- Partitioning link into two stages enables clearer evaluation of roles played by contributing sources and processes

Figure 1. Causal link between tropospheric weather and space weather

Questions:

- Q1) To discover the sources of wave-like plasma perturbations in the F-region ionosphere
- Q2) To determine the relative role of dynamo action and more direct mechanical forcing in the formation of wave-like plasma perturbations.



Approach: Measure phase delay between the velocity components parallel and perpendicular to the magnetic field and the plasma density perturbation.

- High-cadence plasma densities
- Vector ion drift

SORTIE vs. C/NOFS

❖ Science

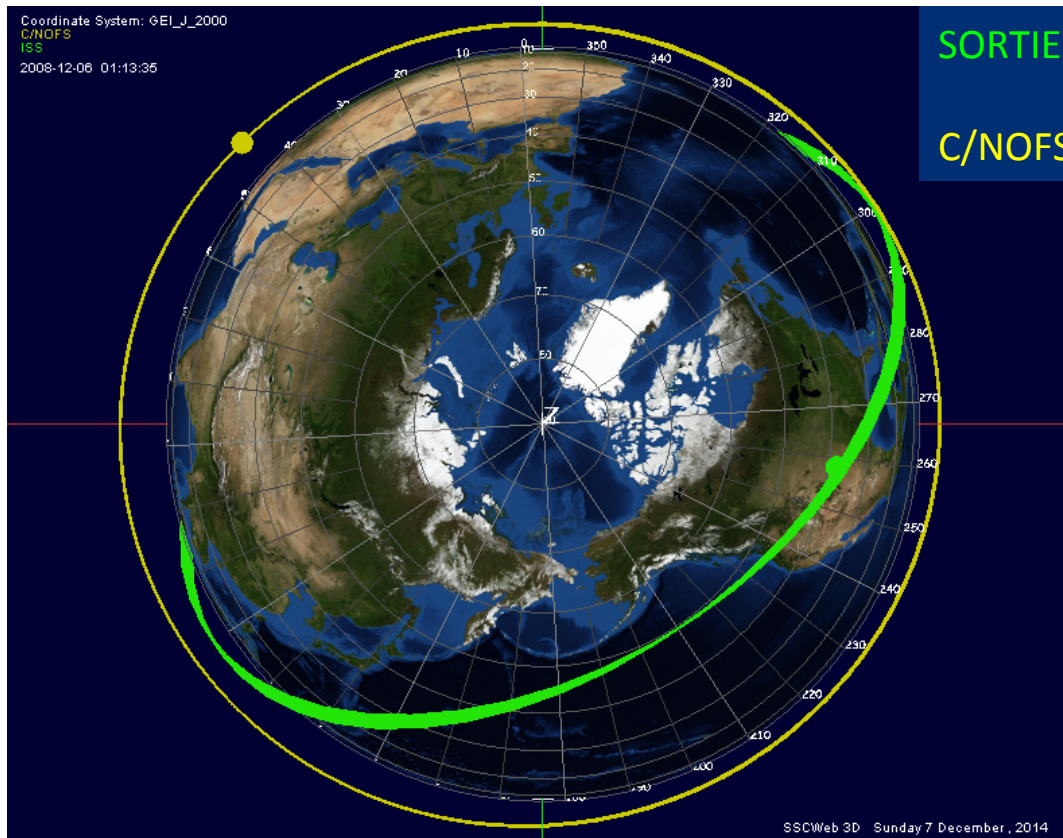
❖ Technology

❖ Applications

Bringing It All Together



Coordinate System: GEl_J_2000
C/NOFS
ISS
2008-12-06 01:13:35

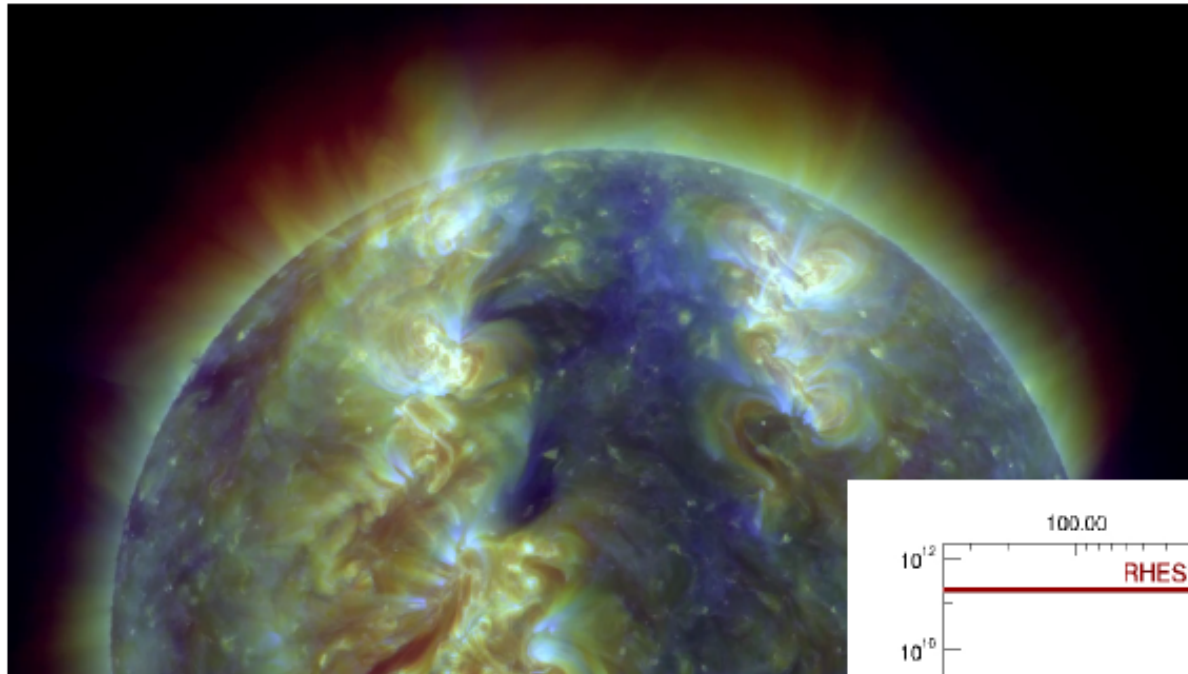


SORTIE at 52° inclination

C/NOFS orbit in 2009

- The near-circular SORTIE orbit will provide more optimal ionospheric sampling
- SORTIE will complement C/NOFS data by sampling from a different orbit
- SORTIE will provide data after C/NOFS reentry which is expected sometime in 2015
- SORTIE instruments: mini-IVM, micro-PLP
- C/NOFS instruments: IVM, PLP, NWM, CORISS, CERTO, VEFI
- SORTIE will complement the NASA ICON mission that will launch in 2017

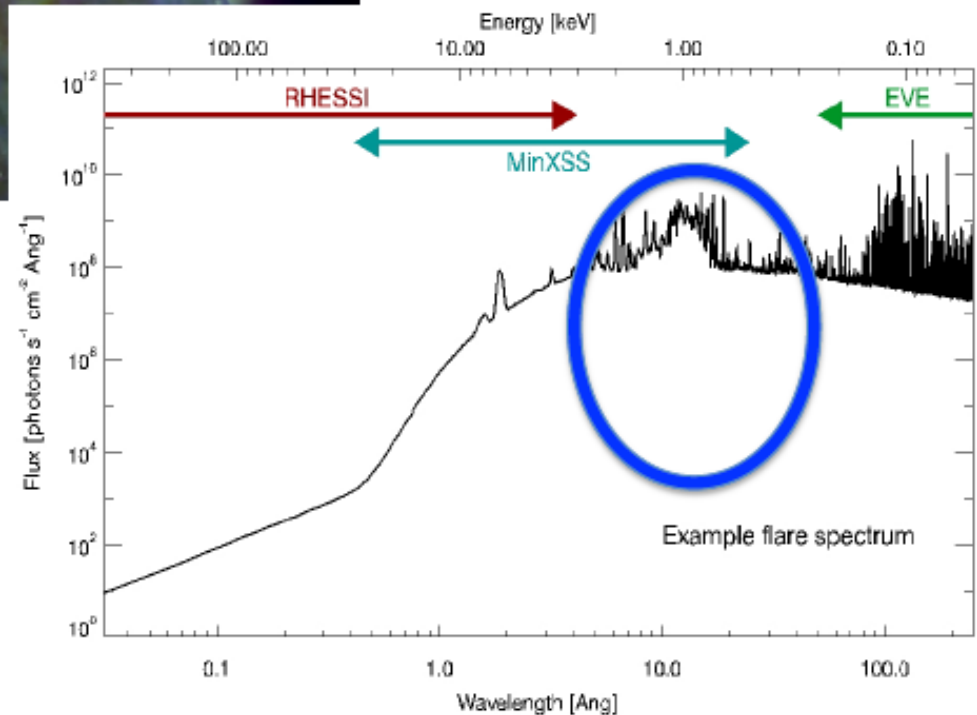
MinXSS Science Motivation #1 – Flares



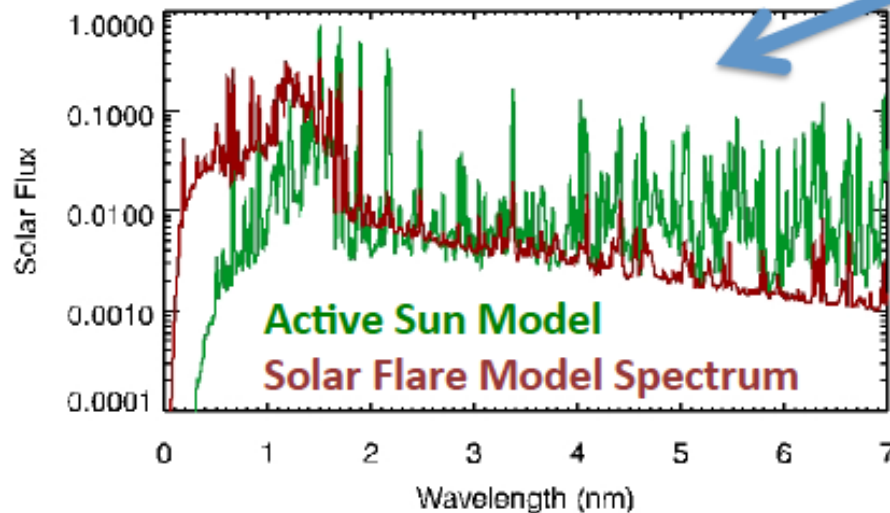
To better understand the energy distribution of solar flare soft X-ray (SXR) emissions:

- Flare energetics
- Nanoflare heating of the corona

- Largest flare enhancements are expected near 10-20 Å (1-2 nm) from solar models, but there are very few SXR spectra measured during flare events [Rodgers *et al.* 2006].
- Rocket X123 measurements suggest nanoflare heating in the more active Sun measurement in 2013 than in the quiet Sun measurement in 2012 [Caspi *et al.*, 2015].



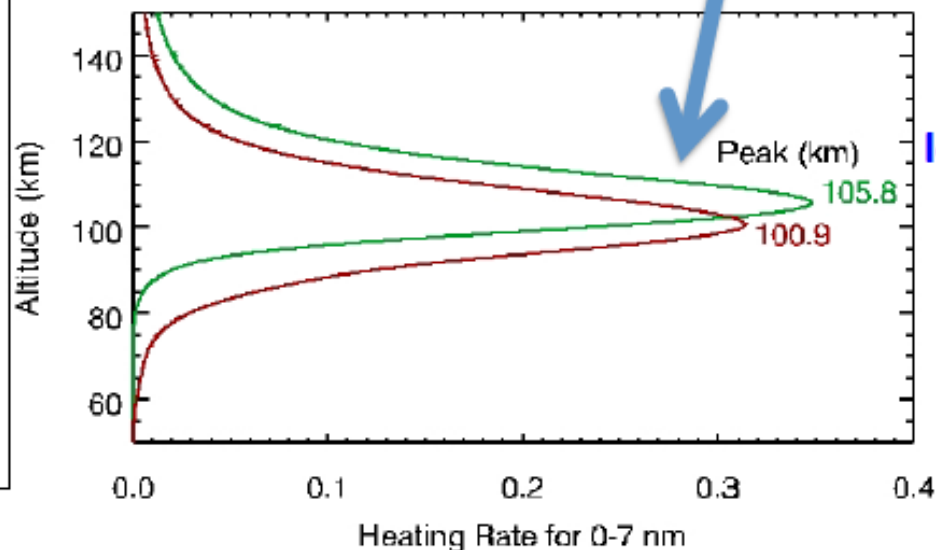
MinXSS Science Motivation #2 - Earth



- These two spectra have the same amount of soft x-ray (SXR: 0.1-10 nm) irradiance, but they have very different spectral distribution.
- Earth's atmospheric cross sections are steep in the 0.1-10 nm range.
- Consequently, the solar SXR radiation is deposited into different layers of the atmosphere, thus contributing to the confusion of solar energy input.

To better understand the solar SXR impact on Earth's ionosphere, thermosphere, and mesosphere (ITM):

- Focus is on E layer energetics and response to flares



Thermosphere
Ionosphere F Layer
Ionosphere E Layer
Ionosphere D Layer
Mesosphere
Stratosphere